Reviews.

Zinc and Lead Region of North Arkansas. By John C. Branner (Arkansas Geological Survey, Annual Report 1892, 396 pp., Little Rock, 1901.)

The lead and zinc deposits of the Ozark region have received attention from the geological surveys of Arkansas, Missouri, Kansas, and the federal government. The United States Geological Survey and the University Geological Survey of Kansas will shortly have out reports on the subject. Missouri, through her geological survey, has already published an exhaustive account of the deposits in two large volumes, by Mr. Arthur Winslow. After delays of nearly ten years, Arkansas has at last seen fit to make appropriations for the publication of the report on the zinc and lead deposits of the north part of the state. It is by the former state geologist, Dr. J. C. Branner.

The publication of Dr. Branner's report has long been looked forward to by all interested in the subject of lead and zinc. In many respects it is the most welcome contribution to our knowledge of the geology of the Ozark region that has yet been made.

Preliminary to the consideration of the ores is a short description of the surface relief of the region, illustrated by an excellent photographic reproduction of Branner's Relief Model of Arkansas. The zinc and lead deposits described are located chiefly north of the Arkansas river. "The region here included under the name of Ozark plateau embraces nearly all of that part of the Ozark mountains within the state of Arkansas. It includes almost the entire region between the Arkansas river and the Missouri line, and between the St. Louis, Iron Mountain & Southern railway and the Indian Territory line. The Ozark region in Arkansas is made up of three plateaus that rise like ragged-edged steps one above another, each with a few outliers standing out upon the next step below."

In order of their importance, the zinc ores of northern Arkansas are sphalerite, smithsonite and calamine, besides several other minerals of zinc which do not occur in sufficient quantities to entitle them to be looked upon as ores.

The zinc ores are regarded as having been deposited by underground waters. Emphasis is laid on their accumulation along synclinal troughs and water-way breccias. "The details of the theory of the accumulation of the Arkansas ores along synclines and other water-ways were first suggested by field observations made in this region in 1889, and the whole theory has been much strengthened by subsequent work."

According to their genetic relations there are three kinds of sulphide ores: (*a*) the bedded deposits, which are contemporaneous with the rocks in which they occur; (*b*) the veins and other fracture deposits in which the ores are of later age than the accompanying beds, and (*c*) the breccia deposits not formed on fractures, but likewise of later age than the accompanying beds. In addition to the sulphide ores there are carbonate and silicate ores, derived by alteration from the sulphides and forming genetically a fourth class.

Regarding the origin of the bedded deposits, it is stated that they "have originated for the most part where we now find them." The cherts are made of silica of organic origin, that is, they were deposited over the sea bottom as silicious skeletons of diatoms or other microscopic remains of plants or animals. The zinc came from the adjacent land areas of the period in which these beds were laid down. Upon entering the sea the zinc-bearing waters had their zinc contents precipitated in the form of sphalerite or zinc sulphide by the organic matter that contributed the silica of the chert beds. The zinc crystallized out while these silicious sediments were yet soft and yielding. In time the sediments hardened and formed the firm, flinty rocks and pressed closely about the zinc blende crystals.

"The crystals of zinc blende, however, were not originally as large as we now find them in the disseminated ores, even where these crystals are no larger than a pin head. They were at first even microscopic, but, as Ostwald has pointed out, there is a tendency in such cases for the small crystals to pass into solution and to recrystallize upon the larger ones which grew at the expense of the small ones. In the bedded deposits this took place before the enclosing sediments were hardened."

The vein deposits are those occupying the spaces left by fractures in the strata. The ores are confined to the fractured zone and to its immediate walls. When the ore is found in the walls it seldom penetrates them to any considerable depth, but is confined to small

fractures that seem to be parts of the great fissures. In appearance the fissure ores are not different from the bedded deposits. But they are stated to have a very different origin. The ores of this class have all been brought into their present position by solution, probably from the Ordovician bedded deposits.

The question of the origin of the breccia ores "has been one of the most puzzling problems encountered in the zinc regions. The only theory for these formations that seems tenable is that of the apparently irregular masses of breccia, that is, the breccias not upon fault and such like fractures, have been formed along ancient underground water-courses."

One of the most suggestive points brought out in this consideration of the zinc ores is the relation of synclines to the presence of ores. Dr. Branner says: "If the hypothetical history here assigned the north Arkansas zinc ores is thus far correct, we are forced to conclude that the geologic structure of the region is of the utmost importance in the determination of the present distribution of the ores. In an elevated region of approximately horizontal or very gently folded sediments, the waters falling upon the ground and soaking into the earth tend to seek the bottoms of the synclinal troughs. The process of ore accumulation in such a region would therefore tend to carry the ores into the synclines. The rocks of the zinc region, although not far from horizontal, are gently folded. Wherever folds have been exposed in the zinc mines the bottoms and sides of these folds have been found richer in zinc than the adjacent portions of the same beds. This is a rule to which I know but few exceptions. The inference seems to be warranted that the synclinal troughs should be located and examined for the richer zinc accumulations."

Of exceptional interest at this time are the notes on the faults of north Arkansas. For the first time in the consideration of the zinc region something tangible regarding these structures and their character is made available. The throw of the faults, though never very great, is sometimes four hundred feet or more. The character of the folds found in the vicinity of the faults is shown by numerous figures.

The illustrations are unusually good.

C. R. KEYES.